CLAIMS

[Claim(s)]
1. In an anesthesia apparatus, this anesthesia apparatus has a mass spectrometer (11), An anesthesia apparatus, wherein inhalation of air, expiration, or at least one returned gas constituents of anesthetic-gas content gas are quantitatively measured using this mass spectrometer (11) and this measured value is used for control of this anesthesia apparatus.
2. Anesthesia apparatus according to claim 1 for measuring simultaneously gas constituents, i.e., oxygen, anesthetic gas, and nitrogen quantitatively.
3. Anesthesia apparatus according to claim 1 or 2 by which safeguard is controlled by mass spectrometer (11).
4. Anesthesia apparatus given in any 1 paragraph to claims 1-3 by which mass spectrometer (11) is combined with measurement point via one or more capillary tubes.

* NOTICES *

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2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
Analysis apparatus for the surveillance of a xenon content anesthetic gas The anesthetization using the xenon as an anesthetic gas is already written in the medicine-related technical book from before for many years. There are a series of medical advantages today as compared with laughter gas (N_2O) in ordinary use. However, broad introduction of the xenon to the above-mentioned application and a high raw material cost remarkable until now disagreed.
The difference of such cost decreased dramatically by development in recent years. the improved anesthesia process (low Floe process (Low Flow-Technik); the minimum Floe process (Minimal-Flow Technik)) to which gas consumption decreased in this development -- and, The recovery method (the Germany patent No. 4411533 specification (C1)) for the called xenon mixture which enables return of the operation ingredient xenon to the inside of an anesthesia gas circulation way is included.
Mixing of the anesthetic-gas ingredient was performed by handicraft until now.
The inhaler is written in the Germany patent application public presentation No. 3712598 specification (A1). The xenon is mentioned with other anesthetic gases as an anesthetic gas. This anesthesia machine is available via the gas analyser which is not specified in detail.
In the Germany patent application public presentation No. 3635004 specification (A1), the mass spectrometer for the surveillance of respiratory gas is written, and this mass spectrometer measures the amount of carbon dioxide in this case.
The xenon which is an anesthetic gas is remarkably difficult to measure by analysis as noble gas. The gas analyser of daily use in the case of the anesthesia machine is unsuitable to fixed-quantity measurement of a xenon.
Since [in use of the xenon as an anesthetic gas / return of the xenon from expired gas / cost], it is absolute necessity. The measurement which in return of the xenon of a under [inhalation of air (inhaler side)] the gas mixture thing-constituent of an inlet-side branch (Inspirationszweig) is perfect, and can be trusted is inescapable. On the other hand, in order to enable it to change to an auxiliary feeding means (for example, gas bomb) promptly in the case of failure of a device so that the quality of the gas in the case of return all over a respiratory circuit can be secured eternally, The gas mixture thing-constituent supplied by recovery must be supervised continuously.On the other hand, in order [which supervises advance of a medical practitioner's anesthesia individually / which can carry out things and is controlled] to be able to carry out things, the presentation of the anesthetic gas in a respiratory circuit must be pursued continuously. The nitrogen content to which it produces medically as [both] a remains impurity for which it can substitute, and the enrichment in a respiratory circuit must be additionally restricted from recovery must be supervised [others / an operation ingredient, i.e., a xenon, and a respiratory ingredient, i.e., oxygen,].
Automation of mixing of the anesthetic gas with which the respiratory gas ingredient other than the surveillance which the gas composition of inspired gas (gas for inspiration) and expired gas (gas

called by the patient) can trust was mixed and returned is a technical problem of this invention.
The object of this invention is an anesthesia apparatus which has a mass spectrometer for quantitive measurement of at least one gas constituents in inspired gas, expired gas, or the returned anesthetic-gas content gas.
A mass spectrometer is usually combinable with the gas stream which should be analyzed via a film or a capillary tube. The combination through a film has a fault of high gas consumption (about 5 l/h). The combination through a capillary tube is advantageous. Thus, the gas consumption can decrease to about 0.5 l/h. The capillary tube can consist of a plastic, metal, or glass. In the case of especially comparatively long measuring time and a comparatively long capillary tube, a capillary tube consists of metal advantageously. For example, the capillary tube which has the length 6-10m can be used. The pliability regarding the place about installation of a mass spectrometer becomes possible by this.
In the case of the anesthesia apparatus by this invention, a mass spectrometer is used advantageously at simultaneous quantitive measurement of the gas constituents of inspired gas, expired gas, or the returned anesthetic-gas content gas, i.e., oxygen, an anesthetic gas (for example, xenon), and nitrogen. Measurement is expandable to another gas constituents, for example, carbon dioxide.
An anesthesia apparatus is constituted as the mass spectrometer is advantageously combined via the gas lead pipe and control valve of the anesthetic gas collected by inspired gas, expired gas, and a case, or the returned respiratory gas.
The anesthesia apparatus has at least one mass spectrometer.
this mass spectrometer is built into the anesthesia machine, or it separates from the nearness (for example, -- as what is called a rucksack state) of the anesthesia machine, or the anesthesia machine several meters, and it can be installed (to for example, inside of next Takumi).
The mass spectrometer is functionally combined with the anesthesia machine. By two measurement channels, a mass spectrometer is simultaneous or can measure the gas which could supervise anesthesia gas circulation and was supplied from the xenon recovery system by turns in the short cycle.
As a mass spectrometer, the device of marketing of a lei bolt company (Leybold AG) (Koeln) of the name of the eco-tech 500 (Ecotec500), It is suitable, and this device has a very compact structure form, and can already use a computer interface for transmission of a measurement signal. To an old mass spectrometer, it is usable without the expensive device peripheral equipment made usual, and, in the case of the device to which a sampling part ****s, the device of this marketing provides an actual measurement. This mass spectrometer is designed 1-100 a.m.u.s for time base ranges. Restriction of HE in this time base range makes a very compact structure form possible. The xenon which has the atomic mass 132 cannot be satisfactorily measured with such a device. This problem was solved by being ionized doubly because of measurement of a xenon (formation of Xe^{2+}).
Measurement by mass spectrometry is usually performed with the cycle rate (Taktrate) of about 1 measurement / second. A cycle rate can also be chosen from this short or for a long time.
A recovery system is indirectly supervised from the anesthesia machine by the surveillance of the anesthetic-gas content gas in the case of penetration into the anesthesia machine. In spite of this indirect surveillance, it is because the restriction about the possibility of the reaction in the case of the obstacle of operation in recovery does not occur at all but it, that is, the collected gas are correctly controlled by the part used.
The computer which usually exists in the anesthesia machine enables evaluation of the analytical value for a process control further. The anesthetic gas (for example, xenon) and the fresh anesthetic gas (from a gas bottle and the source of an anesthetic gas) which were collected are automatically mixable so that it may be adjusted in the anesthesia parameter set by the medical practitioner by a valve control device or the flow control device. Usually, in order to have to compensate the loss of the xenon produced within a device by addition of a fresh xenon, an

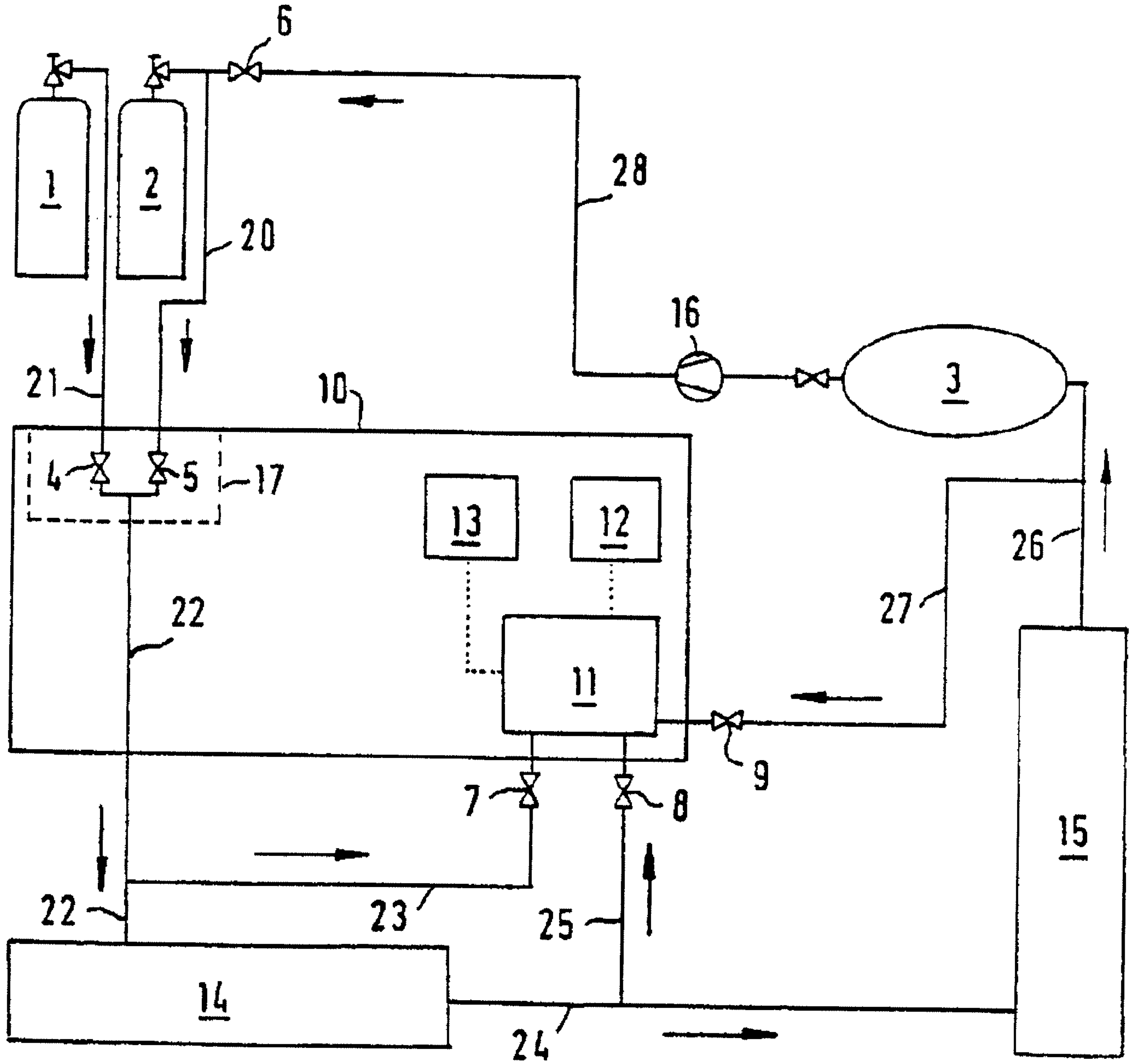
automatic regulation of the gas stream based on an analysis result provides a big advantage. The control of a mass spectrometer supported by the computer enables continuous record of the anesthesia parameter about gas, and follows, and satisfies the demand to perfect record of anesthesia advance.
It can supervise and record what kind of substance mixture was supplied to the recovery system from the anesthesia machine by the sampling part in the call side branch of an anesthesia circuit. When two or more anesthesia machine is combined with one recovery system, regardless of other mass spectrometers, each mass spectrometer can also interrupt the gas supply from a recovery system in the case of an obstacle, or can also control the whole recovery system. When the surveillance of an anesthesia circuit is omitted for simplification, a recovery system can also be supervised with one mass spectrometer, and this mass spectrometer is arranged between the gas outlet of a recovery system, and the turning point to the anesthesia machine according to the number of the connected anesthesia machine.
The above-mentioned analysis apparatus is also applicable to the anesthesia which used old laughter gas. Therefore, the surveillance of an anesthesia circuit can be performed regardless of the selected anesthetic gas. Therefore, this is a big advantage when the anesthesia machine of the latest style permits operation with a xenon or laughter gas selectively. In this case, a collection unit is not usually used for anesthesia using laughter gas. When the discarding treatment (vor-Ort-Vernichtung) in the spot of the laughter gas mixture which flows out of the reasons of environmental protection or work being safe in the future cannot but be needed, such a discarding treatment unit can be similarly supervised, controlled or recorded with a mass spectrometer.
The above-mentioned inclusion to the device which consists of the selection and anesthesia machine, and recovery system of a mass spectrometer of the mass range which decreased in number is realizable about the expense than which it is more notably [than the expense which made satisfy the above-mentioned functional demand thoroughly, and was expected to the further old mass spectrometer] less. Therefore, the above-mentioned anesthesia apparatus enables on expense advantageous operation in which xenon anesthesia is still more economical.
Drawing 1 shows the schematic diagram of the anesthesia apparatus as an example. This anesthesia apparatus The gas supply devices 1 (oxygen source) and 2 (a source of a xenon, the "I-th feed unit"), It has 3 (a xenon storage container, the collected xenon), the anesthesia machine 10, the control unit 12 (a computer or a microprocessor), the mass spectrometer 11, the monitor 13, and the xenon collection unit 15. Inspired gas is mixed via the valves 4 and 5 from the source 2 of a xenon and/or the xenon from 3 from oxygen from the oxygen source 1. The valves 4 and 5 are the so-called components of the gas mixture box (Gasmischbox) 17. Inspired gas (inhalation of air) is supplied to a patient via the lead pipe 22. Expired gas (expiration)
The xenon recovery system 15 is supplied via ** and the lead pipe 24. The lead pipe 26 has reached the xenon storage container 3 from this xenon recovery system. The lead pipe 28 has reached the lead pipe 20 via the valve 6 from this storage container 3.
This lead pipe 20 has reached all over the gas mixture box.
the lead pipes 22 (inhalation of air) and 24 (expiration) and a lead pipe -- the exit of 26 xenon recovery system is combined with the mass spectrometer via the by-pass lines 23, 25, and 27. The by-pass lines 23, 25, and 27 have the controllable valves 7, 8, and 9, respectively. The valves 4, 5, 6, 7, 8, and 9 are controlled by a control unit (computer). This control unit is playing a role of the usual control similarly.
The mass spectrometer has one or more interfaces (computer interface).
The measurement signal which shows an analysis result is transmitted to a control unit via this interface.

With a control unit, the content of gas constituents (for example, oxygen, a xenon, nitrogen) is calculated from a measurement signal. The control unit is connected to the monitor 13.

All the pertinent information is displayed on this monitor.
The xenon recovery system 15 is realizable according to the Germany patent application public presentation No. 4411533 specification, for example. Other xenon recovery methods can also be used similarly.
For the :1. anesthesia start to which anesthesia which uses an anesthesia apparatus is advantageously carried out in many following stages (example which uses a xenon as an anesthetic gas), a patient has inspired gas (oxygen-xenon mixture) inhaled, and the presentation of inhalation of air and expiration is measured in this case. A patient's lung and respiratory channel are scavenged in the case of this start face. In the case of this face, expiration contains nitrogen.
2. When the presentation of expiration is stabilized and a nitrogen content descends to an acceptable value, a xenon recovery system (determination of the starting point of a xenon recovery system) is connected.
3. Anesthesia reaches a stillness face. The presentation of inhalation of air and expiration is started. Additionally, the presentation of the xenon gas from a xenon recovery system can be supervised.
4. It changes from an anesthetic gas to usual respiratory gas (air) for the end of anesthesia. Especially in the case of this face, the nitrogen content in expiration is important. When a nitrogen content exceeds full limits (for example, 5 % of the weight), a lead pipe has combination with the expired gas of a xenon recovery system canceled promptly.
The stages 1-4 need inhalation of air, expiration, and to always control the gas composition of a recovery system advantageously. Control is performed using one or more mass spectrometers. One mass spectrometer is enough by the connection by which the mass spectrometer was controlled. In order to be able to carry out safety study regardless of a control unit, the measurement signal of a mass spectrometer is possible (abgreifbar) in a pickup with a direct device advantageously. In achievement of specific full limits, alarm equipment can be operated. In a gap nonpermissible from the ideal value of a presentation of inhalation of air in supply of the collected xenon, it can change at the pure xenon from a storage compressed gas vessel (source of a xenon) (change of the xenon circuit to the 1st - and the feed unit for urgent). The actual measurement of gas composition is advantageously compared with the reference value of a comparison gas mixture (from a bellows (Druckdose)) direct or in a control unit in a mass spectrometer. Amendment of a mass spectrometer is similarly performed based on the comparison gas mixture from a bellows. Advantageously, mass part **** is adjusted so that alarm equipment may operate in descent of the pressure in a bellows. The automation of an anesthesia apparatus can also include the control for adjustment of the degree of gas flow rate about control of the valve supported by the computer. It is publicly known to a person skilled in the art how control of a gas stream is constituted.
The conditions for anesthesia by few gas streams BAUMU (JanBaum), It is indicated in "Die Narkose mit niedrigemFrischgasfluss", the 2nd edition, Draegerwerk AG, Luebeck, and the pamphlet of 1994 (ISBN 3-921958-90-3).
This literature is referred to.

Source of reference mark list 1 oxygen-source 2 xenon 3 [Mass spectrometer 12 control unit (computer)] Xenon storage containers 4, 5, 6, 7, 8, and 9 Control valve 10 Anesthesia machine 11 13 Monitor 14 patient 15 xenon recovery-system 16 Pump 17 gas-mixture boxes 20, 21, 22, 23, 24, and 25 Gas lead pipe.

[Translation done.]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Donnerhack et al.

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(54) **ANALYTICAL CONFIGURATION FOR MONITORING XENON-CONTAINING ANAESTHETIC GAS**

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(52) **U.S. Cl.** **250/281**

(58) **Field of Search** 250/281, 282, 250/288

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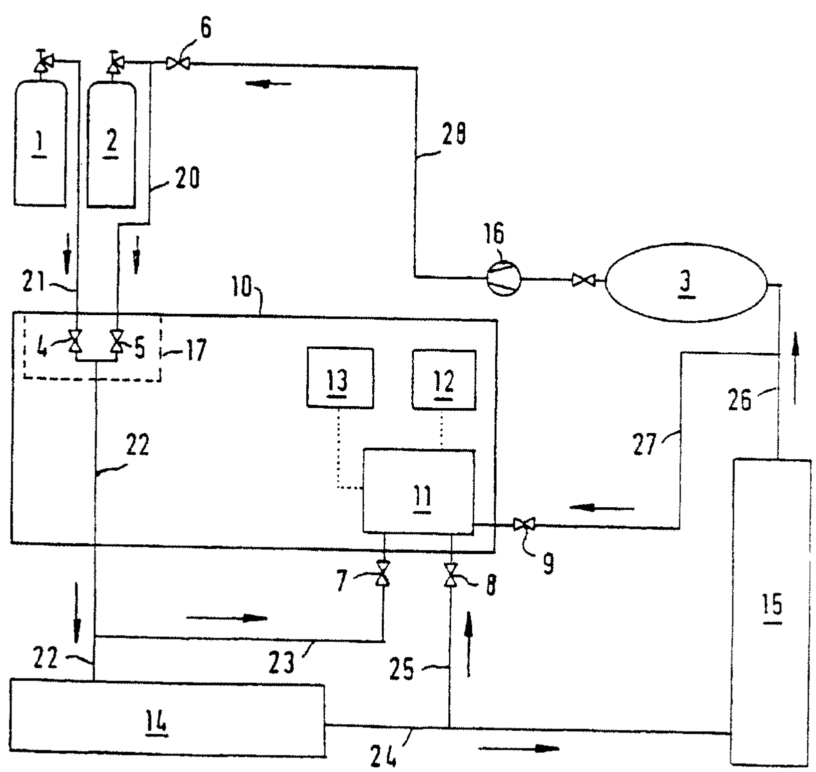
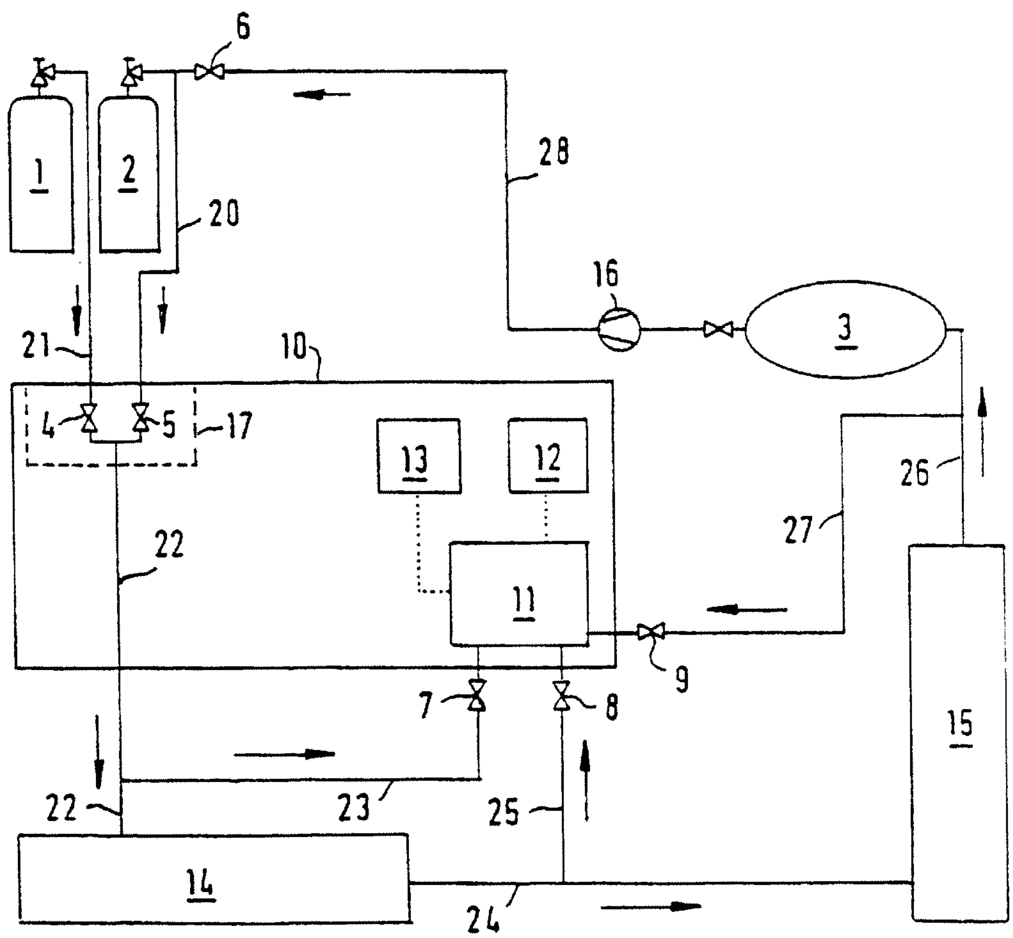
(57) **ABSTRACT**

An anesthesia system has ventilation gas supply flow structure for supplying ventilation gas to a patient. Structure is provided for the exhaled gas and for recycling the anesthetic gas-containing gas. The system uses a mass spectrometer connected to these flow structures to measure the content of at least one gas component in the gases and to control the flow through at least one of the flow structures in accordance with at least one measured value of the gas content.

17 Claims, 1 Drawing Sheet

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ANALYTICAL CONFIGURATION FOR MONITORING XENON-CONTAINING ANAESTHETIC GAS

BACKGROUND OF THE INVENTION

Anesthesia with xenon as an anesthetic gas has been described in the specialist medical literature for many years now. There are a number of medical advantages compared with laughing gas (N_2O) which is customary nowadays. However, the widespread introduction of xenon for this application has hitherto been impeded by the very much higher materials costs.

Developments in recent years have drastically reduced this difference in costs. These include improved anesthetic methods with low gas consumption (low-flow technique; minimal-flow technique) and methods for recovering the exhaled xenon mixture which make it possible to recycle the active component xenon in the anesthetic gas circulation (DE 44 11 533 C1).

Hitherto, admixture of anesthetic gas components has taken place manually.

DE 37 12 598 A1 describes an inhalation anesthetic machine. Besides other anesthetic gases xenon is mentioned as anesthetic gas. The machine has a gas analyzer, which is not characterized in detail.

DE 36 35 004 A1 describes a mass spectrometer for monitoring respiratory gases, the mass spectrometer measuring the carbon dioxide level.

Analytical determination of the anesthetic gas xenon is difficult as it is an inert gas. Gas analyzers customary in anesthetic machines are unsuitable for quantitative determination of xenon.

When xenon is used as anesthetic gas it is indispensable to recycle xenon from the exhaled gas for cost reasons. When xenon is recycled into the ventilation gas (inspiration side), satisfactory and reliable measurements of the gas mixture composition in the inspiration branch is indispensable. On the one hand, the gas mixture composition delivered from the recovery must be monitored continuously so that it is possible permanently to ensure the gas quality on recycling into the breathing circulation, and to switch over immediately to an auxiliary supply (for example gas cylinder) in the event of faults in the machine. On the other hand, the composition of the anesthetic gas in the breathing circulation must be continuously followed so that the clinician can monitor and control the progress of anesthesia individually. Besides the active component xenon and the respiratory component oxygen, it is additionally necessary to monitor the nitrogen content which is included as medically acceptable residual impurity from the recovery and whose accumulation in the breathing circulation must be limited. Besides reliable monitoring of the gas composition of inspired gas (gas for inhalation) and expired gas (gas exhaled by the patient), it is an object of the invention to automate the mixing of the respiratory gas components and the admixing of recycled anesthetic gas.

The invention now relates to an anesthesia system with mass spectrometer for quantitative measurement of at least one gas component in the ventilation gas, exhaled gas or recycled anesthetic gas-containing gas.

Mass spectrometers can in general be connected via a membrane or capillary to a gas stream to be analyzed. Coupling via a membrane has the disadvantage of a large gas consumption (for example around 5 l/h). Coupling capillaries is advantageous. The loss of gas can be reduced to about 0.5 l/h in this way. The capillary can consist of plastic, metal or glass. Metal capillaries are preferred, especially with prolonged measurement periods and lengthy capillaries. The capillaries may be employed, for example, with a length of from 6 to 10 meters. This permits flexibility in the site for setting up the mass spectrometer.

The mass spectrometer in the anesthesia system according to the invention is preferably used for simultaneous quantitative measurement of the gas components oxygen, anesthetic gas (for example xenon) and nitrogen in the inspired gas, expired gas or recycled anesthetic gas-containing gas. The measurement can be extended to other gas components such as carbon dioxide.

The anesthesia system is advantageously designed so that the mass spectrometer is connected via control valves to the gas lines for inspired gas, expired gas and, where appropriate, recovered anesthetic gas or recycled respiratory gas.

The anesthesia system contains at least one mass spectrometer which can be integrated into the anesthetic machine, or can be set up in the direct vicinity of the anesthetic machine (for example as so-called backpack) or some meters away from the anesthetic machine (for example in an adjacent room). The mass spectrometer is functionally connected to the anesthetic machine. The mass spectrometer can both monitor the anesthetic gas circulation and measure the gas fed in from the xenon recovery via two measurement channels simultaneously or alternately in short cycles.

A suitable mass spectrometer is a commercial apparatus supplied by Leybold AG (Cologne) with the designation Ecotec 500, which has a very compact design and already has a computer interface for transmitting the measured signal. This commercial apparatus can be employed without the elaborate apparatus peripherals hitherto customary with mass spectrometers and, when the sampling points are appropriately arranged, provides real-time measured data. The mass spectrometer is designed for the mass range from 1 to 100 atomic mass units. The restriction to this mass range makes a very compact design possible. Xenon has an atomic mass of 132 and cannot be determined directly with such an apparatus. The problem has been solved by doubly ionizing xenon (formation of Xe^{2+}) for the measurement.

The mass spectrometric measurements usually take place with clock-pulse rates of 1 measurement/second. The clock-pulse rate can also be chosen to be shorter or longer.

The monitoring of the recovered anesthetic gas-containing gas on entry into the anesthetic machine means that the recovery system is indirectly monitored from the anesthetic machine. Despite this indirect monitoring, there are no restrictions of any kind on the possibility of reacting to faults in the recovery operation, because the recovered gas is monitored exactly where it is used.

The computer normally present in an anesthetic machine furthermore makes it possible to use the analytical data for process control. Recovered anesthetic gas (for example xenon) and fresh anesthetic gas (from the gas cylinder, anesthetic gas source) can be automatically mixed via a valve control or flow regulator so that the anesthesia parameters preselected by the clinician are set up. Since the losses of xenon which regularly occur in the system must be compensated by adding fresh xenon, automatic control of the gas flows on the basis of the analytical results offers great advantages. In addition, the computer-assisted control of the mass spectrometer makes it possible continuously to document the gas-related anesthesia parameters and thus meets the requirement for continuous documentation of the progress of anesthesia.

It is furthermore possible to monitor and document, through a sampling point in the expiratory branch of the anesthesia circuit, which mixture of substances is fed from the anesthetic machine into the recovery.

If several anesthetic machines are coupled to a single recovery system, it is possible for each mass spectrometer independently of the others to interrupt the gas supply from the recovery in the event of faults or else to block the recovery system entirely. If, for reasons of simplicity, monitoring of the anesthesia circuit is dispensed with, the recovery can also be monitored by a single mass spectrometer which, depending on the number of connected anesthetic machines, is positioned between the recovery gas outlet and the point of branching to the anesthetic machines.

The described analytical configuration can also be used for anesthesia with conventional laughing gas. It is therefore possible to monitor the anesthesia circuit irrespective of the anesthetic gas chosen. This is particularly advantageous when modern anesthetic machines permit operation with xenon or laughing gas as selected. As a rule, no recovery unit is employed for anesthesia with laughing gas. If, for environmental protection or worker safety reasons, in future it becomes necessary for the outflowing laughing gas mixture to be destroyed on site, it will also be possible for such a disposal unit likewise to be monitored, controlled or documented with a mass spectrometer.

The choice of a mass spectrometer with reduced mass range and the described linkage into the system of anesthetic machine and recovery system entirely meet the functional requirements described above and, furthermore, can be implemented at costs which are distinctly below those to be expected with conventional mass spectrometers. This means that the described anesthesia system is reasonably priced and, furthermore, permits economic operation of xenon anesthesia.

BRIEF DESCRIPTION OF THE DRAWING

FIG. **1** shows a diagram of an anesthesia system in accordance with this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1** shows a diagram of an anesthesia system as example. The anesthesia system contains the gas supplies **1** (oxygen source), **2** (xenon source, "first supply"), **3** (xenon store, recovered xenon), an anesthetic machine **10**, control unit **12** (computer or microprocessor), mass spectrometer **11** and monitor **13**, and xenon recovery unit **15**. The ventilation gas is mixed via valves **4** and **5** from oxygen from the oxygen source **1** and from xenon from the xenon source **2** and/or **3**. Valves **4** and **5** are components of a so-called gas mixing box **17**. The ventilation gas (inspired) is fed to the patient via line **22**. The exhaled gas (expired) is fed to the xenon recovery **15** via line **24**. Line **26** leads from the xenon recovery to the xenon store **3**. Line **28** leads from the store **3** via valve **6** into line **20**, which leads into the gas mixing box. Lines **22** (inspired), **24** (expired) and line **26** (xenon recovery outlet) are connected to the mass spectrometer via bypass lines **23**, **25** and **27**. Bypass lines **23**, **25** and **27** each have a controllable valve **7**, **8** and **9**. Valves **4**, **5**, **6**, **7**, **8** and **9** are controlled by the control unit (computer). The control unit also undertakes the conventional control tasks. The mass spectrometer has one or more interfaces (computer interfaces) via which the measured signal, which represents the analytical result, is passed to the control unit. The control unit calculates the content of the gas components (for example oxygen, xenon, nitrogen) from the measured signal. The control unit is connected to the monitor **13** on which all the relevant information is shown. The xenon recovery **15** can take place, for example, as described in DE 44 11 533. Other xenon recovery methods can likewise be employed.

Anesthesia with the anesthesia system advantageously takes place in the following stages (example with xenon as anesthetic gas):

1. At the start of anesthesia, the patient is ventilated with a ventilation gas (oxygen/xenon mixture) and, during this, the composition of the inspired gas and expired gas is determined. In this initial phase, the lungs and airways of the patient are flushed. The expired gas contains nitrogen in this phase.
2. When the composition of the expired gas has stabilized and the nitrogen content has fallen to an acceptable level, the xenon recovery (determination of the starting point of the xenon recovery) is switched on.
3. The anesthesia reaches a stationary phase. The compositions of the inspired gas and expired gas are monitored. It is additionally possible to monitor the composition of the xenon gas from the xenon recovery.
4. The anesthesia is terminated by switching over from anesthetic gas to normal respiratory gas (air). The nitrogen content in the expired gas is of particular interest in this phase. As soon as the nitrogen content exceeds a limit (for example 5 percent by weight), the line with the expired gas is uncoupled from the xenon recovery.

Stages 1 to 4 require continuous monitoring of the composition of the inspired, expired and, advantageously, recovered gases. The monitoring takes place with one or more mass spectrometers. Controlled coupling of the mass spectrometer means that one mass spectrometer is sufficient.

It is advantageous for it to be possible to pick up the measured signal from the mass spectrometer directly on the machine in order to make a safety test possible independently of the control unit. When certain limits are reached, an alarm can be triggered. It is possible when recovered xenon is being fed in, and when the composition of the inspired gas shows an unacceptable difference from the desired value, to switch over to pure xenon from the reserve compressed gas cylinder (xenon source) (Switching over from xenon circulation to first and emergency supplies). It is advantageous for the actual value of the gas composition to be compared with a reference value from a reference gas mixture (for example from a pressure element) either directly in the mass spectrometer or in the control unit. The mass spectrometer can likewise be calibrated using a reference gas mixture from a pressure element. The mass spectrometer is advantageously also arranged so that an alarm is triggered if the pressure in the pressure element falls.

Automation of the anesthesia system may not only relate to computer-assisted control of valves but also comprise control of regulators for setting the gas flow rate. The design of a control for the gas flow rate is familiar to the skilled person.

Conditions for anesthesia with a low gas flow rate are described in the booklet by Jan Baum "Die Narkose mit niedrigem Frischgasfluß" [Anesthesia with a Low Fresh Gas Flow Rate], 2nd edition, Drägerwerk AG, Lübeck, 1994 (ISBN 3-921958-90-3), to which reference is made.

List of Reference Numbers

1 oxygen source
2 xenon source
3 xenon store
4, **5**, **6**, **7**, **8**, **9**, valve, controlled

10 anesthetic machine
11 mass spectrometer
12 control unit (computer)
13 monitor
14 patient
15 xenon recovery
16 pump
17 gas mixing box
20, 21, 22, 23, 24, 25 gas line

What is claimed is:

1. In an anesthesia system having ventilation gas supply flow structure for supplying ventilation gas to a patient, exhaled gas flow structure for receiving exhaled gas from the patient and recycled anesthetic gas-containing gas flow structure for receiving recycled anaesthetic gas, the improvement being a mass spectrometer connected to the flow structures, the mass spectrometer measuring a content of at least one gas component in the ventilation exhaled or recycled anaesthetic gases, and the mass spectrometer controlling flow of the ventilation, exhaled or recycled anaesthetic gases through at least one of the flow structures in accordance with a measured value of the content.

2. Anesthesia system as claimed in claim **1** including structure for the mass spectrometer for simultaneous quantitative measurement of oxygen, anesthetic gas and nitrogen.

3. Anesthesia system as claimed in claim **2**, wherein the mass spectrometer controls a safety unit.

4. Anesthesia system as claimed in claim **3**, wherein the mass spectrometer is connected via one or more capillaries to one or more measuring points.

5. Anesthesia system as claimed in claim **4**, wherein the mass spectrometer is connected via one or more capillaries to the measuring points, and the length of the capillaries is in the range from 1 to 10 meters.

6. Anesthesia system as claimed in claim **5**, wherein the mass spectrometer is connected via one or more capillaries to the measuring points, and the capillaries consist of plastic, metal or glass.

7. Anesthesia system as claimed in claim **6**, wherein the mass spectrometer is integrated into an anesthetic machine, and the mass spectrometer is attached as backpack to the anesthetic machine.

8. Anesthesia system as claimed in claim **6**, wherein the mass spectrometer is integrated into an anesthetic machine or is spatially separated from the machine.

9. Anesthesia system as claimed in claim **1**, wherein xenon is employed as anesthetic gas, and the recovery of xenon from the exhaled gas is monitored or controlled by the mass spectrometer.

10. Anesthesia system as claimed in claim **9**, wherein the mass spectrometer makes continuous measurements for several measuring points alternately.

11. Anesthesia system as claimed in claim **1**, wherein the mass spectrometer controls a safety unit.

12. Anesthesia system as claimed in claim **1**, wherein the mass spectrometer is connected via one or more capillaries to one or more measuring points.

13. Anesthesia system as claimed in claim **1**, wherein the mass spectrometer is connected via one or more capillaries to measuring points, and the length of the capillaries is in the range from 1 to 10 meters.

14. Anesthesia system as claimed in claim **1**, wherein the mass spectrometer is connected via one or more capillaries to measuring points, and the capillaries consist of plastic, metal or glass.

15. Anesthesia system as claimed in claim **1**, wherein the mass spectrometer is integrated into an anesthetic machine, and the mass spectrometer is attached as backpack to the anesthetic machine.

16. Anesthesia system as claimed in claim **1**, wherein xenon is employed as anesthetic gas, and the recovery of xenon from the exhaled gas is monitored or controlled by the mass spectrometer.

17. Anesthesia system as claimed in claim **1**, wherein the mass spectrometer makes continuous measurements for several measuring points alternately.

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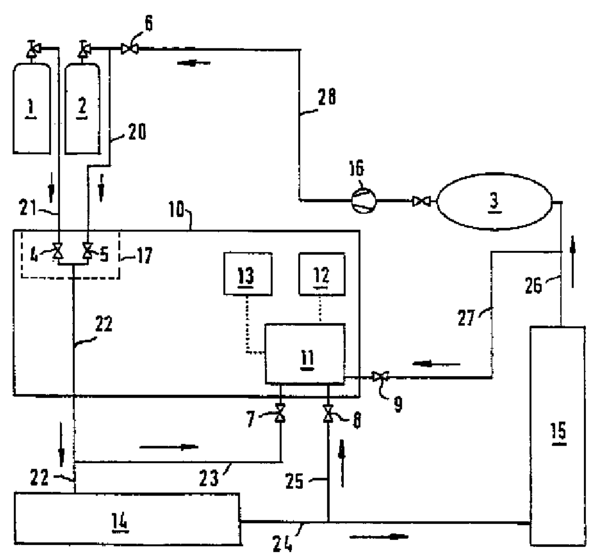
最終頁に続く

(54)【発明の名称】　キセノン含有麻酔ガスの監視のための分析装置

(57)【要約】
吸入ガス中の酸素、麻酔ガス及び窒素の同時測定のための質量分析計（１１）を有する麻酔器（１０）が記載されている。質量分析計（１１）によって測定された吸気及び呼気のガス組成は、測定信号として、制御ユニット（１２）、例えばコンピュータ、に伝達される。麻酔器（１０）は、このようにして自動化することができる。



【特許請求の範囲】

１．　麻酔装置において、該麻酔装置が質量分析計（１１）を有しており、該質量分析計（１１）を用いて吸気、呼気又は返送された麻酔ガス含有ガスの少なくとも１つのガス成分が定量的に測定され、かつこの測定値が該麻酔装置の制御に使用されることを特徴とする麻酔装置。

２．　ガス成分即ち酸素、麻酔ガス及び窒素を同時に定量的に測定するための、請求項１記載の麻酔装置。

３．　質量分析計（１１）によって安全装置が制御される、請求項１又は２記載の麻酔装置。

４．　質量分析計（１１）が１つ以上の毛管を介して測定箇所に結合されている、請求項１から３までのいずれか１項に記載の麻酔装置。

５．　質量分析計（１１）が１つ以上の毛管を介して測定箇所に結合されておりかつ毛管の長さが１～１０ｍの範囲内である、請求項１から４までのいずれか１項に記載の麻酔装置。

６．　質量分析計（１１）が１つ以上の毛管を介して測定箇所に結合されておりかつ該毛管がプラスチック、金属又はガラスからなる、請求項１から５までのいずれか１項に記載の麻酔装置。

７．　質量分析計（１１）が麻酔器中に組み込まれているか、質量分析計（１１）がリュックサック状態で

麻酔器に取り付けられているか又は質量分析計（１１）が本来の麻酔器から空間的に分離されている、請求項１から６までのいずれか１項に記載の麻酔装置。

８．　キセノンが麻酔ガスとして使用されかつ呼出ガスからのキセノンの回収が質量分析計（１１）によって監視もしくは制御される、請求項１から７までのいずれか１項に記載の麻酔装置。

９．　質量分析計（１１）によって複数の測定箇所が交替で連続的に測定される、請求項１から８までのいずれか１項に記載の麻酔装置。

１０．麻酔器の制御方法において、質量分析計（１１）を吸気、呼気又は返送された麻酔ガス含有ガスの少なくとも１つのガス成分の定量的測定に使用し、かつ

質量分析計（１１）の測定信号を弁（４～９）の制御に使用することを特徴とする、麻酔器の制御方法。
１１．麻酔器又は麻酔装置の自動化のための質量分析計（１１）の使用。
１２．麻酔器運転中の吸入ガス、呼出ガス又は返送された麻酔ガス含有ガスの複数成分の同時測定のための質量分析計（１１）の使用。

【発明の詳細な説明】

キセノン含有麻酔ガスの監視のための分析装置

麻酔ガスとしてキセノンを用いた麻酔法は、既に何年も前から医学関係の専門書に記載されている。今日常用の笑気ガス（N_2O）に比して、一連の医学的な利点がある。しかしながら、上記適用へのキセノンの幅広い導入には、これまで著しく高い原料費が対立していた。

近年の発展によりこのような経費の差は、劇的に減少した。この発展には、ガス消耗が減少された改善された麻酔プロセス（低フロー法(Low Flow-Technik); 最小フロー法(Minimal-Flow Technik)）ならびに、麻酔ガス－循環路中への作用成分キセノンの返送を可能にする呼出されたキセノン混合物に対する回収方法（ドイツ国特許第４４１１５３３号明細書（Ｃ１））が含まれる。

麻酔ガス成分の混入は、これまで手作業により行なわれていた。

ドイツ国特許出願公開第３７１２５９８号明細書（Ａ１）には吸入麻酔器が記載されている。麻酔ガスとして他の麻酔ガスとともにキセノンが挙げられている。該麻酔器は、詳しく明示されていないガス分析装置を介して利用可能である。

ドイツ国特許出願公開第３６３５００４号明細書（Ａ１）には呼吸ガスの監視のための質量分析計が記載されており、この際、該質量分析計は、二酸化炭素量を測定する。

麻酔ガスであるキセノンは、貴ガスとして、分析により測定することは、著しく困難である。麻酔器の場合には常用のガス分析装置は、キセノンの定量測定には不適当である。

麻酔ガスとしてのキセノンの使用の場合には呼出ガスからのキセノンの返送は、経費的な理由から絶対必要である。吸気中（吸入器側）へのキセノンの返送の場合には、吸入側支流(Inspirationszweig)のガス混合物－組成物の申し分なくかつ信頼しうる測定は、不可避である。一方で、呼吸循環路中への返送の際のガスの品質を永久的に保障することができるようにかつ装置の故障の際に直ちに補助供給手段（例えばガスボンベ）に切り替えることができるようにするため、回収によって供給されるガス混合物－組成物は連続的に監視されなければならない

。他方では、医師が麻酔の進行を個別に監視することできかつ制御することできるようにするため、呼吸循環路中の麻酔ガスの組成は、連続的に追跡されなければならない。作用成分即ちキセノン及び呼吸成分即ち酸素の他に付加的に、回収から、医学的に代替可能な残留不純物として共に生じかつ呼吸循環路におけるその富化が制限されなければな

らない窒素含量は、監視されなければならない。

吸入ガス（吸息用ガス）及び呼出ガス（患者から呼出されたガス）のガス組成の信頼しうる監視の他に、呼吸ガス成分の混合及び返送された麻酔ガスの混入の自動化は、本発明の課題である。

本発明の対象は、吸入ガス、呼出ガス又は返送された麻酔ガス含有ガス中の少なくとも１つのガス成分の定量的測定のための質量分析計を有する麻酔装置である。

質量分析計は、通常、膜又は毛管を介して分析すべきガス流と結合することができる。膜を介した結合は、高いガス消耗（約５ｌ／ｈ）という欠点を有している。毛管を介した結合は、有利である。このようにしてガス消耗は、約０．５ｌ／ｈに減少することができる。毛管は、プラスチック、金属又はガラスからなることができる。有利に毛管は、殊に比較的長い測定時間及び比較的長い毛管の場合には、金属からなる。例えば長さ６～１０ｍを有する毛管は、使用することができる。このことによって質量分析計の設置に関する場所的な柔軟性が可能となる。

本発明による麻酔装置の場合には質量分析計は、有利に、吸入ガス、呼出ガス又は返送された麻酔ガス含有ガスのガス成分即ち酸素、麻酔ガス（例えばキセノン）及び窒素の同時の定量的な測定に利用される。測定は、別のガス成分、例えば二酸化炭素に拡大するこ

とができる。

麻酔装置は、有利に、質量分析計が、吸入ガス、呼出ガス及び場合により回収された麻酔ガスもしくは返送された呼吸ガスのガス導管と制御弁を介して結合さ

れているように構成される。
　麻酔装置は、少なくとも１つの質量分析計を有しており、この質量分析計は、麻酔器に組み込まれているか、麻酔器の間近に（例えばいわゆるリュックサック状態として）か、又は麻酔器から数メートル離して（例えば隣の室中に）設置されることができる。質量分析計は、機能的に麻酔器に結合されている。質量分析計は、２つの測定流路によって同時にか又は短いサイクルで交替で、麻酔ガス－循環を監視することができかつキセノン－回収装置からの供給されたガスを測定することができる。
　質量分析計として、エコテック５００（Ecotec500）の名称の、レイボルト社（Leybold AG）（Koeln）の市販の装置は、適当であり、この装置は、きわめてコンパクトな構造様式を有しておりかつ既に測定信号の転送にコンピューターインターフェースを利用することができる。該市販の装置は、これまでの質量分析計には通常とされる高価な装置周辺機器なしで使用可能でありかつ、試料採取箇所の相応する装置の場合に実測値を提供する。該質量分析計は、１～１００原子質量単位の測定範囲用に設計されている。この測定範囲内への制限が、きわめてコンパクトな構造様式を可能にする。原子質量１３２を有するキセノンは、このような装置で問題なく測定することはできない。この問題は、キセノンが測定のために二重にイオン化（Xe^{2+}の形成）されることによって解決された。
　質量分析法による測定は、通常、ほぼ１測定／秒のサイクル速度(Taktrate)で行なわれる。サイクル速度は、これより短くもしくは長く選択することもできる。
　麻酔器中への進入の際の麻酔ガス含有ガスの監視によって、回収装置は、間接的に麻酔器から監視される。この間接的な監視にもかかわらず、回収における運転の障害の場合の反応の可能性に関しての制限は全く発生せず、それというのも、回収されたガスが、使用される箇所で正確に制御されるからである。
　麻酔器中に通常存在している計算機は、さらに、プロセス制御のための分析値の評価を可能にする。回収された麻酔ガス（例えばキセノン）及び新鮮な麻酔ガ

ス（ガス容器、麻酔ガス源からの）は、弁制御装置又は流量調整装置によって、医師により設定された麻酔パラメータに調整されるように自動的に混合することができる。通常装置内で生ずるキセノンの損失を新鮮なキセノンの添加によって補償しなければならないため、分析結果に基づくガス流の自動調整は、大きな利点を提供する。さらに、計算機により支援された、質量分析計の制御は、ガスに関する麻酔パラメータの連続的な記録を可能にし、かつ従って麻酔進行の完璧な記録に対する要求を満足させる。

さらに、麻酔循環路の呼出側支流における試料採取箇所によって、いかなる物質混合物が麻酔器から回収装置に供給されたかを監視かつ記録することができる。

複数の麻酔器が１つの回収装置に結合されている場合には、各質量分析計は、他の質量分析計とは無関係に、障害の際に回収装置からのガス供給を中断することもできるし、或いは回収装置全体を制止することもできる。簡易化のために麻酔循環路の監視が省略される場合には、回収装置は、１つの質量分析計によって監視することもでき、この質量分析計は、接続された麻酔器の数に応じて、回収装置のガス出口と麻酔器への分岐点の間に配置されている。

上記の分析装置は、これまでの笑気ガスを用いた麻酔に使用することもできる。従って、麻酔循環路の監視は、選択された麻酔ガスに無関係に行なうことができる。従ってこのことは、最新式の麻酔器が選択的にキセノン又は笑気ガスでの運転を許容する場合には、大きな利点である。この場合には笑気ガスを用いた麻酔には、通常、回収ユニットは使用されない。将来環境保護もしくは作業安全上の理由から流出される笑気ガス混合物の現場での廃棄処理（vor-Ort-Vernichtung）が必要とならざるを得ない場合には、このような廃棄処理ユニットは、同様に質量分析計で監視、制御もしくは記録することができる。

減少された質量範囲の質量分析計の選択及び麻酔器と回収装置からなる装置への上記の組み込みは、上記の機能的な要求を完全に満足させ、かつさらに、これ

までの質量分析計に対して期待されていた費用より顕著に下回る費用について実現可能である。従って上記の麻酔装置は、費用上有利でありかつさらにキセノンー麻酔の経済的な運転を可能にする。

図１は、例としての麻酔装置の概略図を示している。該麻酔装置は、ガス供給装置１（酸素源）、２（キセノン源、「第１供給装置」）、３（キセノン貯蔵容器、回収されたキセノン）、麻酔器１０、制御ユニット１２（コンピュータ又はマイクロプロセッサ）、質量分析計１１及びモニタ１３ならびにキセノンー回収ユニット１５を有している。吸入ガスは、弁４及び５を介して、酸素源１からの酸素からと、キセノン源２及び／又は３からのキセノンからとで混合される。弁４及び５は、いわゆるガス混合ボックス（Gasmischbox）１７の構成要素である。吸入ガス（吸気）は、導管２２を介して患者に供給される。呼出ガス（呼気）は、導管24を介してキセノンー回収装置１５に供給される。該キセノンー回収装置から導管２６は、キセノンー貯蔵容器３に達している。該貯蔵容器３から導管２

８は、弁６を介して導管２０に達しており、この導管２０は、ガス混合ボックス中に達している。導管２２（吸気）、２４（呼気）及び導管２６キセノンー回収装置の出口）は、バイパス導管２３、２５及び２７を介して質量分析計と結合している。バイパス導管２３、２５及び２７はそれぞれ制御可能弁７、８及び９を有している。弁４、５、６、７、８及び９は、制御ユニット（コンピュータ）によって制御される。該制御ユニットは、同様に通常の制御の役割を担っている。質量分析計は、１つ以上のインタフェース（コンピューターインタフェース）を有しており、このインタフェースを介して、分析結果を示す測定信号が制御ユニットに伝達される。

制御ユニットによって、測定信号から、ガス成分（例えば酸素、キセノン、窒素）の含量は、計算される。制御ユニットは、モニタ１３に接続されており、このモニタには全ての関連情報が表示される。キセノンー回収装置１５は、例えばドイツ国特許出願公開第４４１１５３３号明細書に従って実現することができる。他のキセノンー回収方法は、同様に使用することもできる。

麻酔装置を使用した麻酔は、有利に次の諸段階で行なわれる（麻酔ガスとしてキセノンを使用した例）：

１．麻酔開始のために患者は、吸入ガス（酸素－キセノン－混合物）を吸入され、かつこの際、吸気及び呼気の組成が測定される。この開始フェースの際に患者の肺及び呼吸経路は、掃去される。該フェースの場合には呼気は、窒素を含有している。

２．呼気の組成が安定しかつ窒素含量が許容値に降下した場合に、キセノン－回収装置（キセノン－回収装置の始動点の決定）は、接続される。

３．麻酔は、静止フェースに達する。吸気及び呼気の組成は、開始される。付加的に、キセノン－回収装置からのキセノンガスの組成は、監視することができる。

４．麻酔の終了のために麻酔ガスから通常の呼吸ガス（空気）に切り替えられる。このフェースの場合には呼気中の窒素含量が特に重要である。窒素含量が限界値（例えば５重量%）を越えると直ちに導管は、キセノン－回収装置の呼出ガスとの結合を解除される。

段階１～４は、吸気、呼気及び有利に回収装置のガス組成が常に制御されることを必要とする。制御は、１つ以上の質量分析計を用いて行なわれる。質量分析計の制御された接続によって１つの質量分析計で十分である。

安全試験を制御ユニットと無関係に実施することができるようにするために、有利に質量分析計の測定信号は、直接装置でピックアップ可能(abgreifbar)である。特定の限界値の達成の場合には警報装置を作動させることができる。回収されたキセノンの供給の場合には、吸気の組成の理想値からの許容不可能なずれの場合には、貯蔵圧縮ガス容器（キセノン源）からの純粋キセノンに切り替えることができる（第１－及び緊急用供給装置へのキセノン－循環路の切り替え）。有利にガス組成の実測値は、質量分析計中で直接か又は制御ユニット中で参照ガス混合物（例えばベロー(Druckdose)からの）の参照値と比較される。質量分析計の補正は、同様にベローか

らの参照ガス混合物に基づいて行なわれる。質量分析計は、有利に、ベロー内の圧力の降下の場合に警報装置が作動するように調整される。

麻酔装置の自動化は、計算機により支援された弁の制御に関することができるばかりではなく、ガス流速度の調整のための制御を含むこともできる。ガス流の制御がどのように構成されるかは、当業者に公知である。

少ないガス流での麻酔のための条件は、バウム(JanBaum), “Die Narkose mit niedrigem Frischgasfluss″, 第２版, Draegerwerk AG, Luebeck, 1994（ＩＳＢＮ　３－９２１９５８－９０－３）のパンフレットに記載されており、この文献が参照される。

参照符号一覧

１　酸素源

２　キセノン源

３　キセノン貯蔵容器

４、５、６、７、８、９　制御弁

１０　麻酔器

１１　質量分析計

１２　制御ユニット（コンピュータ）

１３　モニタ

１４　患者

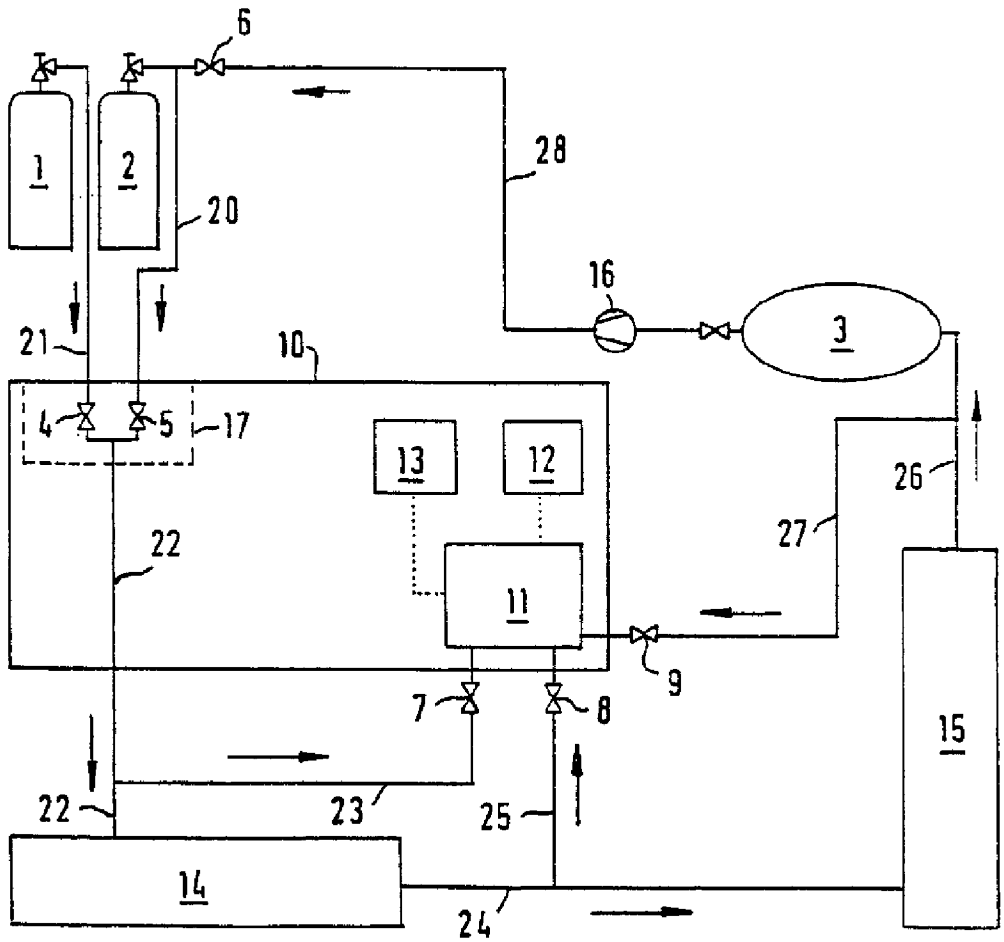
１５　キセノンー回収装置

１６　ポンプ

１７　ガス混合ボックス

２０、２１、２２、２３、２４、２５　ガス導管。

【図１】



【国際調査報告】

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 96/05047

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 A61M16/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 A61M A61B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	MED. PHYS., vol. 11, no. 2, 3 April 1984, pages 209-212, XP000647181 GUR ET AL.: "Simultaneous mass spectrometry and thermoconductivity measurements of end tidal xenon concentrations"	1
Y	see page 209, left-hand column, line 1 - page 211, right-hand column, line 3; figures 1,2	2-13
Y	EP 0 370 637 A (PICKER INT INC) 30 May 1990 see column 3, line 47 - column 4, line 34 see abstract; figure 1A	2-13

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
7 April 1997	22.04.97
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer Zeinstra, H

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 96/05047

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 92 11052 A (BRIGHAM & WOMENS HOSPITAL) 9 July 1992 see page 5, line 17 - page 11, line 9 see abstract; figure 1 ---	1-13
A	CA 2 130 732 A (EVANS DAVID) 24 February 1995 & US 5 474 060 A (EVANS DAVID) 12 December 1995 see column 4, line 26 - column 6, line 54 see abstract; figure 3 -----	5-7

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/EP 96/05047

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0370637 A	30-05-90	US 5140981 A	25-08-92
		DE 68915512 D	30-06-94
		DE 68915512 T	08-09-94
		JP 2184757 A	19-07-90
		US 5024230 A	18-06-91
WO 9211052 A	09-07-92	US 5320093 A	14-06-94
		AU 9167591 A	22-07-92
CA 2130732 A	24-02-95	US 5474060 A	12-12-95

Form PCT/ISA/210 (patent family annex) (July 1992)

フロントページの続き

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CLAIMS

[Claim(s)]
1. In an anesthesia apparatus, this anesthesia apparatus has a mass spectrometer (11), An anesthesia apparatus, wherein inhalation of air, expiration, or at least one returned gas constituents of anesthetic-gas content gas are quantitatively measured using this mass spectrometer (11) and this measured value is used for control of this anesthesia apparatus.
2. Anesthesia apparatus according to claim 1 for measuring simultaneously gas constituents, i.e., oxygen, anesthetic gas, and nitrogen quantitatively.
3. Anesthesia apparatus according to claim 1 or 2 by which safeguard is controlled by mass spectrometer (11).
4. Anesthesia apparatus given in any 1 paragraph to claims 1-3 by which mass spectrometer (11) is combined with measurement point via one or more capillary tubes.

* NOTICES *

JPO and INPIT are not responsible for any
damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
Analysis apparatus for the surveillance of a xenon content anesthetic gas The anesthetization using the xenon as an anesthetic gas is already written in the medicine-related technical book from before for many years. There are a series of medical advantages today as compared with laughter gas (N_2O) in ordinary use. However, broad introduction of the xenon to the above-mentioned application and a high raw material cost remarkable until now disagreed.
The difference of such cost decreased dramatically by development in recent years. the improved anesthesia process (low Floe process (Low Flow-Technik); the minimum Floe process (Minimal-Flow Technik)) to which gas consumption decreased in this development -- and, The recovery method (the Germany patent No. 4411533 specification (C1)) for the called xenon mixture which enables return of the operation ingredient xenon to the inside of an anesthesia gas circulation way is included.
Mixing of the anesthetic-gas ingredient was performed by handicraft until now.
The inhaler is written in the Germany patent application public presentation No. 3712598 specification (A1). The xenon is mentioned with other anesthetic gases as an anesthetic gas. This anesthesia machine is available via the gas analyser which is not specified in detail.
In the Germany patent application public presentation No. 3635004 specification (A1), the mass spectrometer for the surveillance of respiratory gas is written, and this mass spectrometer measures the amount of carbon dioxide in this case.
The xenon which is an anesthetic gas is remarkably difficult to measure by analysis as noble gas. The gas analyser of daily use in the case of the anesthesia machine is unsuitable to fixed-quantity measurement of a xenon.
Since [in use of the xenon as an anesthetic gas / return of the xenon from expired gas / cost], it is absolute necessity. The measurement which in return of the xenon of a under [inhalation of air (inhaler side)] the gas mixture thing-constituent of an inlet-side branch (Inspirationszweig) is perfect, and can be trusted is inescapable. On the other hand, in order to enable it to change to an auxiliary feeding means (for example, gas bomb) promptly in the case of failure of a device so that the quality of the gas in the case of return all over a respiratory circuit can be secured eternally, The gas mixture thing-constituent supplied by recovery must be supervised continuously.On the other hand, in order [which supervises advance of a medical practitioner's anesthesia individually / which can carry out things and is controlled] to be able to carry out things, the presentation of the anesthetic gas in a respiratory circuit must be pursued continuously. The nitrogen content to which it produces medically as [both] a remains impurity for which it can substitute, and the enrichment in a respiratory circuit must be additionally restricted from recovery must be supervised [others / an operation ingredient, i.e., a xenon, and a respiratory ingredient, i.e., oxygen,].
Automation of mixing of the anesthetic gas with which the respiratory gas ingredient other than the surveillance which the gas composition of inspired gas (gas for inspiration) and expired gas (gas

called by the patient) can trust was mixed and returned is a technical problem of this invention.
The object of this invention is an anesthesia apparatus which has a mass spectrometer for quantitive measurement of at least one gas constituents in inspired gas, expired gas, or the returned anesthetic-gas content gas.
A mass spectrometer is usually combinable with the gas stream which should be analyzed via a film or a capillary tube. The combination through a film has a fault of high gas consumption (about 5 l/h). The combination through a capillary tube is advantageous. Thus, the gas consumption can decrease to about 0.5 l/h. The capillary tube can consist of a plastic, metal, or glass. In the case of especially comparatively long measuring time and a comparatively long capillary tube, a capillary tube consists of metal advantageously. For example, the capillary tube which has the length 6-10m can be used. The pliability regarding the place about installation of a mass spectrometer becomes possible by this.
In the case of the anesthesia apparatus by this invention, a mass spectrometer is used advantageously at simultaneous quantitive measurement of the gas constituents of inspired gas, expired gas, or the returned anesthetic-gas content gas, i.e., oxygen, an anesthetic gas (for example, xenon), and nitrogen. Measurement is expandable to another gas constituents, for example, carbon dioxide.
An anesthesia apparatus is constituted as the mass spectrometer is advantageously combined via the gas lead pipe and control valve of the anesthetic gas collected by inspired gas, expired gas, and a case, or the returned respiratory gas.
The anesthesia apparatus has at least one mass spectrometer.
this mass spectrometer is built into the anesthesia machine, or it separates from the nearness (for example, -- as what is called a rucksack state) of the anesthesia machine, or the anesthesia machine several meters, and it can be installed (to for example, inside of next Takumi).
The mass spectrometer is functionally combined with the anesthesia machine. By two measurement channels, a mass spectrometer is simultaneous or can measure the gas which could supervise anesthesia gas circulation and was supplied from the xenon recovery system by turns in the short cycle.
As a mass spectrometer, the device of marketing of a lei bolt company (Leybold AG) (Koeln) of the name of the eco-tech 500 (Ecotec500), It is suitable, and this device has a very compact structure form, and can already use a computer interface for transmission of a measurement signal. To an old mass spectrometer, it is usable without the expensive device peripheral equipment made usual, and, in the case of the device to which a sampling part ****s, the device of this marketing provides an actual measurement. This mass spectrometer is designed 1-100 a.m.u.s for time base ranges. Restriction of HE in this time base range makes a very compact structure form possible. The xenon which has the atomic mass 132 cannot be satisfactorily measured with such a device. This problem was solved by being ionized doubly because of measurement of a xenon (formation of Xe^{2+}).
Measurement by mass spectrometry is usually performed with the cycle rate (Taktrate) of about 1 measurement / second. A cycle rate can also be chosen from this short or for a long time.
A recovery system is indirectly supervised from the anesthesia machine by the surveillance of the anesthetic-gas content gas in the case of penetration into the anesthesia machine. In spite of this indirect surveillance, it is because the restriction about the possibility of the reaction in the case of the obstacle of operation in recovery does not occur at all but it, that is, the collected gas are correctly controlled by the part used.
The computer which usually exists in the anesthesia machine enables evaluation of the analytical value for a process control further. The anesthetic gas (for example, xenon) and the fresh anesthetic gas (from a gas bottle and the source of an anesthetic gas) which were collected are automatically mixable so that it may be adjusted in the anesthesia parameter set by the medical practitioner by a valve control device or the flow control device. Usually, in order to have to compensate the loss of the xenon produced within a device by addition of a fresh xenon, an

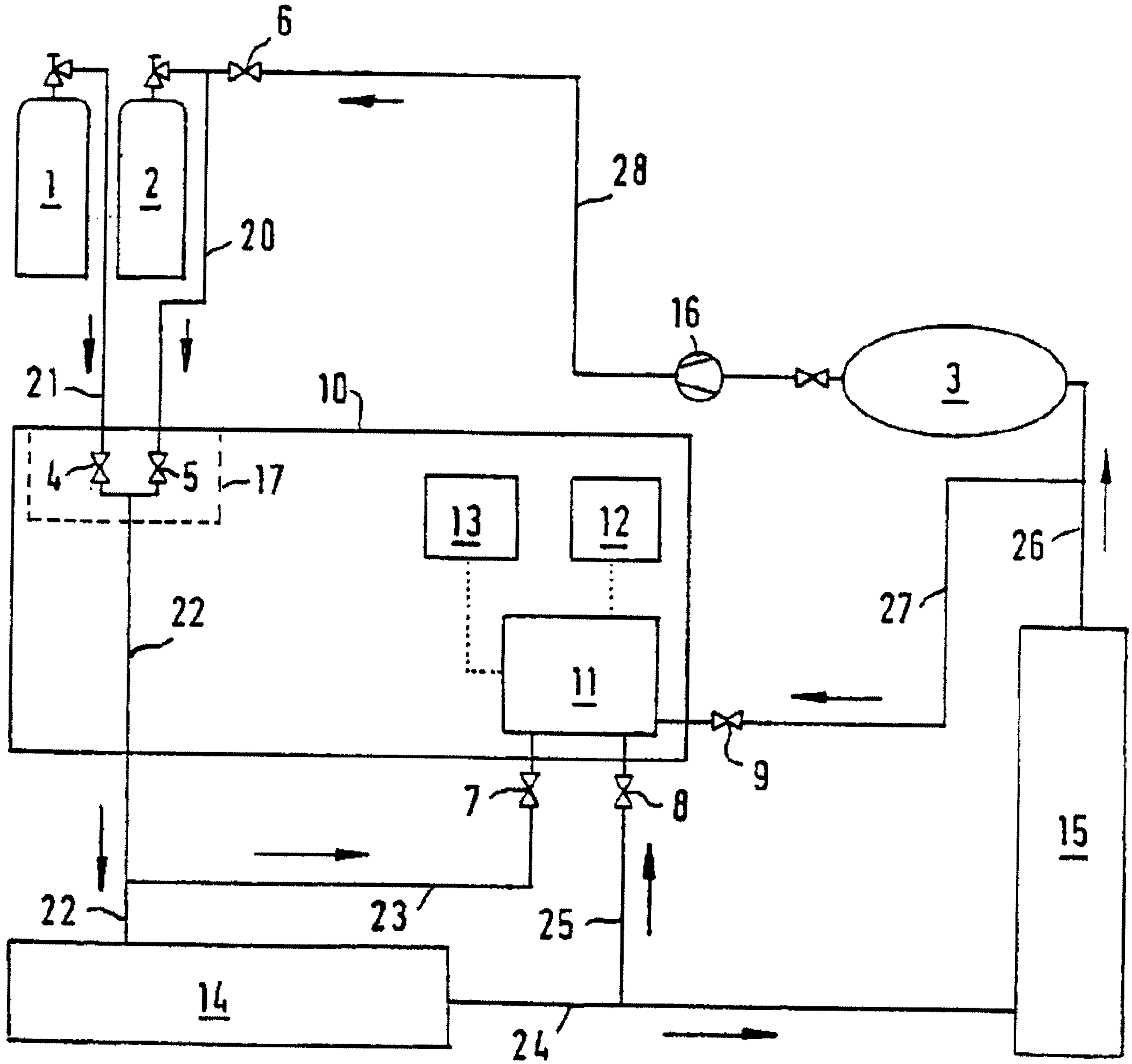
automatic regulation of the gas stream based on an analysis result provides a big advantage. The control of a mass spectrometer supported by the computer enables continuous record of the anesthesia parameter about gas, and follows, and satisfies the demand to perfect record of anesthesia advance.
It can supervise and record what kind of substance mixture was supplied to the recovery system from the anesthesia machine by the sampling part in the call side branch of an anesthesia circuit. When two or more anesthesia machine is combined with one recovery system, regardless of other mass spectrometers, each mass spectrometer can also interrupt the gas supply from a recovery system in the case of an obstacle, or can also control the whole recovery system. When the surveillance of an anesthesia circuit is omitted for simplification, a recovery system can also be supervised with one mass spectrometer, and this mass spectrometer is arranged between the gas outlet of a recovery system, and the turning point to the anesthesia machine according to the number of the connected anesthesia machine.
The above-mentioned analysis apparatus is also applicable to the anesthesia which used old laughter gas. Therefore, the surveillance of an anesthesia circuit can be performed regardless of the selected anesthetic gas. Therefore, this is a big advantage when the anesthesia machine of the latest style permits operation with a xenon or laughter gas selectively. In this case, a collection unit is not usually used for anesthesia using laughter gas. When the discarding treatment (vor-Ort-Vernichtung) in the spot of the laughter gas mixture which flows out of the reasons of environmental protection or work being safe in the future cannot but be needed, such a discarding treatment unit can be similarly supervised, controlled or recorded with a mass spectrometer.
The above-mentioned inclusion to the device which consists of the selection and anesthesia machine, and recovery system of a mass spectrometer of the mass range which decreased in number is realizable about the expense than which it is more notably [than the expense which made satisfy the above-mentioned functional demand thoroughly, and was expected to the further old mass spectrometer] less. Therefore, the above-mentioned anesthesia apparatus enables on expense advantageous operation in which xenon anesthesia is still more economical.
Drawing 1 shows the schematic diagram of the anesthesia apparatus as an example. This anesthesia apparatus The gas supply devices 1 (oxygen source) and 2 (a source of a xenon, the "I-th feed unit"), It has 3 (a xenon storage container, the collected xenon), the anesthesia machine 10, the control unit 12 (a computer or a microprocessor), the mass spectrometer 11, the monitor 13, and the xenon collection unit 15. Inspired gas is mixed via the valves 4 and 5 from the source 2 of a xenon and/or the xenon from 3 from oxygen from the oxygen source 1. The valves 4 and 5 are the so-called components of the gas mixture box (Gasmischbox) 17. Inspired gas (inhalation of air) is supplied to a patient via the lead pipe 22. Expired gas (expiration)
The xenon recovery system 15 is supplied via ** and the lead pipe 24. The lead pipe 26 has reached the xenon storage container 3 from this xenon recovery system. The lead pipe 28 has reached the lead pipe 20 via the valve 6 from this storage container 3.
This lead pipe 20 has reached all over the gas mixture box.
the lead pipes 22 (inhalation of air) and 24 (expiration) and a lead pipe -- the exit of 26 xenon recovery system is combined with the mass spectrometer via the by-pass lines 23, 25, and 27. The by-pass lines 23, 25, and 27 have the controllable valves 7, 8, and 9, respectively. The valves 4, 5, 6, 7, 8, and 9 are controlled by a control unit (computer). This control unit is playing a role of the usual control similarly.
The mass spectrometer has one or more interfaces (computer interface).
The measurement signal which shows an analysis result is transmitted to a control unit via this interface.

With a control unit, the content of gas constituents (for example, oxygen, a xenon, nitrogen) is calculated from a measurement signal. The control unit is connected to the monitor 13.

All the pertinent information is displayed on this monitor.
The xenon recovery system 15 is realizable according to the Germany patent application public presentation No. 4411533 specification, for example. Other xenon recovery methods can also be used similarly.
For the :1. anesthesia start to which anesthesia which uses an anesthesia apparatus is advantageously carried out in many following stages (example which uses a xenon as an anesthetic gas), a patient has inspired gas (oxygen-xenon mixture) inhaled, and the presentation of inhalation of air and expiration is measured in this case. A patient's lung and respiratory channel are scavenged in the case of this start face. In the case of this face, expiration contains nitrogen.
2. When the presentation of expiration is stabilized and a nitrogen content descends to an acceptable value, a xenon recovery system (determination of the starting point of a xenon recovery system) is connected.
3. Anesthesia reaches a stillness face. The presentation of inhalation of air and expiration is started. Additionally, the presentation of the xenon gas from a xenon recovery system can be supervised.
4. It changes from an anesthetic gas to usual respiratory gas (air) for the end of anesthesia. Especially in the case of this face, the nitrogen content in expiration is important. When a nitrogen content exceeds full limits (for example, 5 % of the weight), a lead pipe has combination with the expired gas of a xenon recovery system canceled promptly.
The stages 1-4 need inhalation of air, expiration, and to always control the gas composition of a recovery system advantageously. Control is performed using one or more mass spectrometers. One mass spectrometer is enough by the connection by which the mass spectrometer was controlled. In order to be able to carry out safety study regardless of a control unit, the measurement signal of a mass spectrometer is possible (abgreifbar) in a pickup with a direct device advantageously. In achievement of specific full limits, alarm equipment can be operated. In a gap nonpermissible from the ideal value of a presentation of inhalation of air in supply of the collected xenon, it can change at the pure xenon from a storage compressed gas vessel (source of a xenon) (change of the xenon circuit to the 1st - and the feed unit for urgent). The actual measurement of gas composition is advantageously compared with the reference value of a comparison gas mixture (from a bellows (Druckdose)) direct or in a control unit in a mass spectrometer. Amendment of a mass spectrometer is similarly performed based on the comparison gas mixture from a bellows. Advantageously, mass part **** is adjusted so that alarm equipment may operate in descent of the pressure in a bellows. The automation of an anesthesia apparatus can also include the control for adjustment of the degree of gas flow rate about control of the valve supported by the computer. It is publicly known to a person skilled in the art how control of a gas stream is constituted.
The conditions for anesthesia by few gas streams BAUMU (JanBaum), It is indicated in "Die Narkose mit niedrigemFrischgasfluss", the 2nd edition, Draegerwerk AG, Luebeck, and the pamphlet of 1994 (ISBN 3-921958-90-3).
This literature is referred to.

Source of reference mark list 1 oxygen-source 2 xenon 3 [Mass spectrometer 12 control unit (computer)] Xenon storage containers 4, 5, 6, 7, 8, and 9 Control valve 10 Anesthesia machine 11 13 Monitor 14 patient 15 xenon recovery-system 16 Pump 17 gas-mixture boxes 20, 21, 22, 23, 24, and 25 Gas lead pipe.

[Translation done.]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US006236041B1

(12) **United States Patent**
Donnerhack et al.

(10) **Patent No.: US 6,236,041 B1**
(45) **Date of Patent: May 22, 2001**

(54) **ANALYTICAL CONFIGURATION FOR MONITORING XENON-CONTAINING ANAESTHETIC GAS**

(75) Inventors: **Andreas Donnerhack**, Krefeld; **Ralf Igelhorst**, Tönisvorst; **Peter Neu**, Mülheim; **Renate Schmidt**, Duisburg, all of (DE)

(73) Assignee: **Messer Griesheim GmbH** (DE)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/077,771**

(22) PCT Filed: **Nov. 16, 1996**

(86) PCT No.: **PCT/EP96/05047**

§ 371 Date: **Jun. 1, 1998**

§ 102(e) Date: **Jun. 1, 1998**

(87) PCT Pub. No.: **WO97/20591**

PCT Pub. Date: **Jun. 12, 1997**

(30) **Foreign Application Priority Data**

Jun. 12, 1995 (DE) 195 45 598

(51) **Int. Cl.**[7] **B01D 59/44**

(52) **U.S. Cl.** **250/281**

(58) **Field of Search** 250/281, 282, 250/288

(56) **References Cited**

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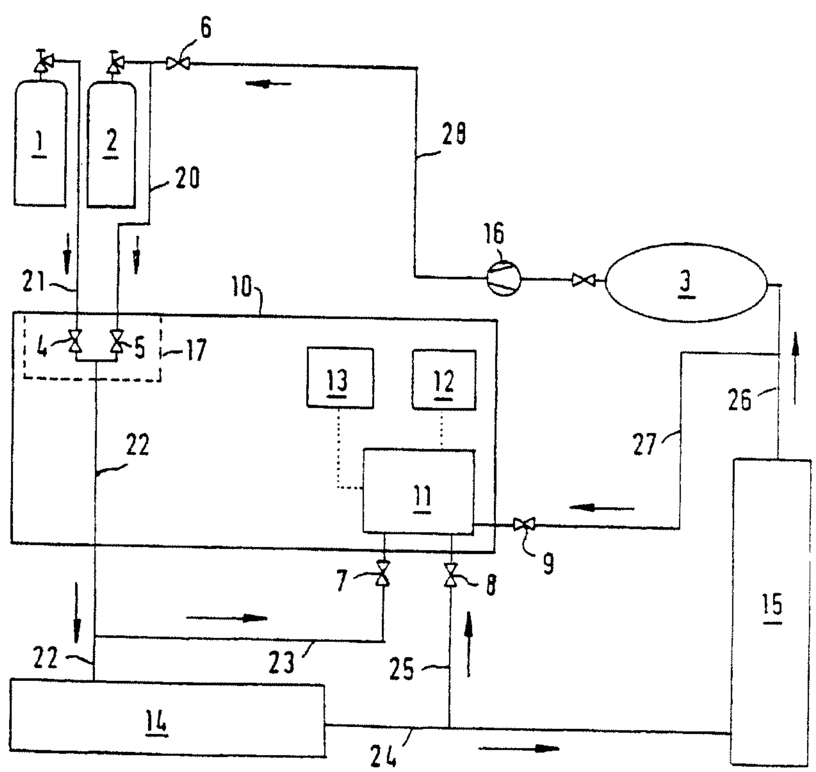
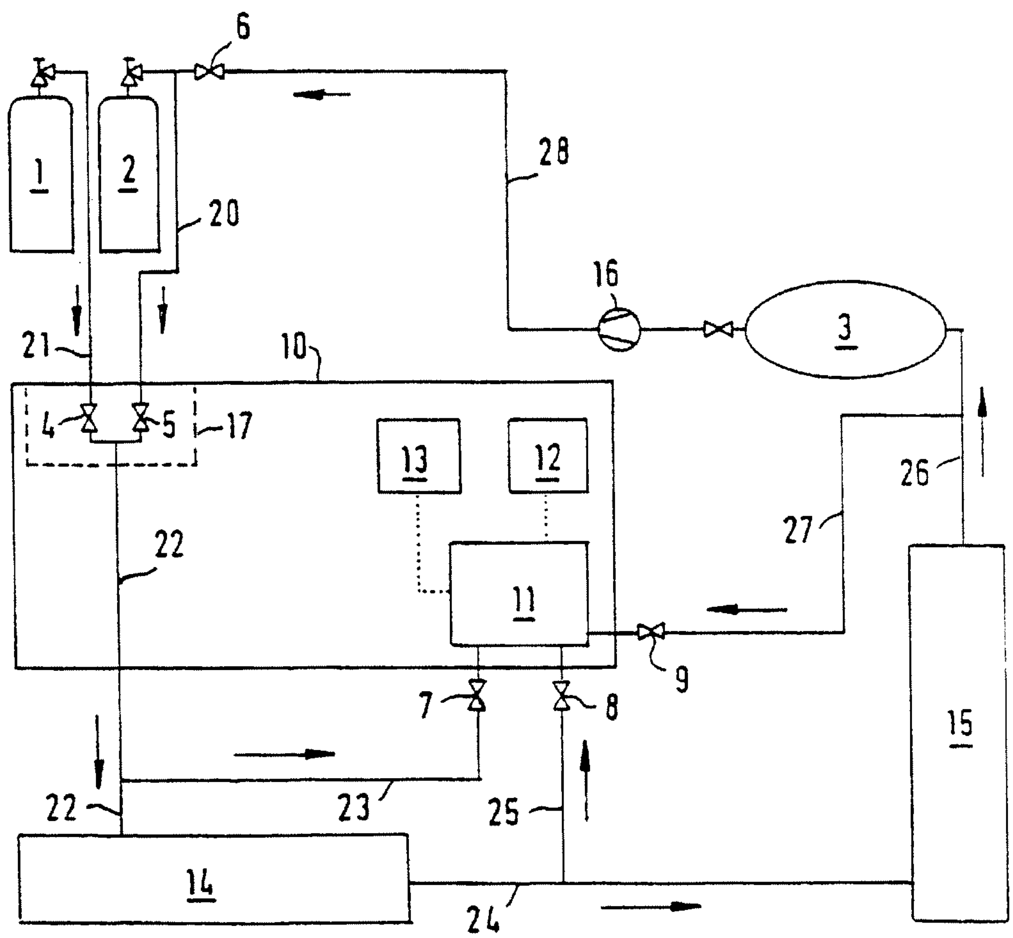
Primary Examiner—Kiet T. Nguyen
(74) *Attorney, Agent, or Firm*—Connolly Bove Lodge & Hutz LLP

(57) **ABSTRACT**

An anesthesia system has ventilation gas supply flow structure for supplying ventilation gas to a patient. Structure is provided for the exhaled gas and for recycling the anesthetic gas-containing gas. The system uses a mass spectrometer connected to these flow structures to measure the content of at least one gas component in the gases and to control the flow through at least one of the flow structures in accordance with at least one measured value of the gas content.

17 Claims, 1 Drawing Sheet

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ANALYTICAL CONFIGURATION FOR MONITORING XENON-CONTAINING ANAESTHETIC GAS

BACKGROUND OF THE INVENTION

Anesthesia with xenon as an anesthetic gas has been described in the specialist medical literature for many years now. There are a number of medical advantages compared with laughing gas (N_2O) which is customary nowadays. However, the widespread introduction of xenon for this application has hitherto been impeded by the very much higher materials costs.

Developments in recent years have drastically reduced this difference in costs. These include improved anesthetic methods with low gas consumption (low-flow technique; minimal-flow technique) and methods for recovering the exhaled xenon mixture which make it possible to recycle the active component xenon in the anesthetic gas circulation (DE 44 11 533 C1).

Hitherto, admixture of anesthetic gas components has taken place manually.

DE 37 12 598 A1 describes an inhalation anesthetic machine. Besides other anesthetic gases xenon is mentioned as anesthetic gas. The machine has a gas analyzer, which is not characterized in detail.

DE 36 35 004 A1 describes a mass spectrometer for monitoring respiratory gases, the mass spectrometer measuring the carbon dioxide level.

Analytical determination of the anesthetic gas xenon is difficult as it is an inert gas. Gas analyzers customary in anesthetic machines are unsuitable for quantitative determination of xenon.

When xenon is used as anesthetic gas it is indispensable to recycle xenon from the exhaled gas for cost reasons. When xenon is recycled into the ventilation gas (inspiration side), satisfactory and reliable measurements of the gas mixture composition in the inspiration branch is indispensable. On the one hand, the gas mixture composition delivered from the recovery must be monitored continuously so that it is possible permanently to ensure the gas quality on recycling into the breathing circulation, and to switch over immediately to an auxiliary supply (for example gas cylinder) in the event of faults in the machine. On the other hand, the composition of the anesthetic gas in the breathing circulation must be continuously followed so that the clinician can monitor and control the progress of anesthesia individually. Besides the active component xenon and the respiratory component oxygen, it is additionally necessary to monitor the nitrogen content which is included as medically acceptable residual impurity from the recovery and whose accumulation in the breathing circulation must be limited. Besides reliable monitoring of the gas composition of inspired gas (gas for inhalation) and expired gas (gas exhaled by the patient), it is an object of the invention to automate the mixing of the respiratory gas components and the admixing of recycled anesthetic gas.

The invention now relates to an anesthesia system with mass spectrometer for quantitative measurement of at least one gas component in the ventilation gas, exhaled gas or recycled anesthetic gas-containing gas.

Mass spectrometers can in general be connected via a membrane or capillary to a gas stream to be analyzed. Coupling via a membrane has the disadvantage of a large gas consumption (for example around 5 l/h). Coupling capillaries is advantageous. The loss of gas can be reduced to

about 0.5 l/h in this way. The capillary can consist of plastic, metal or glass. Metal capillaries are preferred, especially with prolonged measurement periods and lengthy capillaries. The capillaries may be employed, for example, with a length of from 6 to 10 meters. This permits flexibility in the site for setting up the mass spectrometer.

The mass spectrometer in the anesthesia system according to the invention is preferably used for simultaneous quantitative measurement of the gas components oxygen, anesthetic gas (for example xenon) and nitrogen in the inspired gas, expired gas or recycled anesthetic gas-containing gas. The measurement can be extended to other gas components such as carbon dioxide.

The anesthesia system is advantageously designed so that the mass spectrometer is connected via control valves to the gas lines for inspired gas, expired gas and, where appropriate, recovered anesthetic gas or recycled respiratory gas.

The anesthesia system contains at least one mass spectrometer which can be integrated into the anesthetic machine, or can be set up in the direct vicinity of the anesthetic machine (for example as so-called backpack) or some meters away from the anesthetic machine (for example in an adjacent room). The mass spectrometer is functionally connected to the anesthetic machine. The mass spectrometer can both monitor the anesthetic gas circulation and measure the gas fed in from the xenon recovery via two measurement channels simultaneously or alternately in short cycles.

A suitable mass spectrometer is a commercial apparatus supplied by Leybold AG (Cologne) with the designation Ecotec 500, which has a very compact design and already has a computer interface for transmitting the measured signal. This commercial apparatus can be employed without the elaborate apparatus peripherals hitherto customary with mass spectrometers and, when the sampling points are appropriately arranged, provides real-time measured data. The mass spectrometer is designed for the mass range from 1 to 100 atomic mass units. The restriction to this mass range makes a very compact design possible. Xenon has an atomic mass of 132 and cannot be determined directly with such an apparatus. The problem has been solved by doubly ionizing xenon (formation of Xe^{2+}) for the measurement.

The mass spectrometric measurements usually take place with clock-pulse rates of 1 measurement/second. The clock-pulse rate can also be chosen to be shorter or longer.

The monitoring of the recovered anesthetic gas-containing gas on entry into the anesthetic machine means that the recovery system is indirectly monitored from the anesthetic machine. Despite this indirect monitoring, there are no restrictions of any kind on the possibility of reacting to faults in the recovery operation, because the recovered gas is monitored exactly where it is used.

The computer normally present in an anesthetic machine furthermore makes it possible to use the analytical data for process control. Recovered anesthetic gas (for example xenon) and fresh anesthetic gas (from the gas cylinder, anesthetic gas source) can be automatically mixed via a valve control or flow regulator so that the anesthesia parameters preselected by the clinician are set up. Since the losses of xenon which regularly occur in the system must be compensated by adding fresh xenon, automatic control of the gas flows on the basis of the analytical results offers great advantages. In addition, the computer-assisted control of the mass spectrometer makes it possible continuously to document the gas-related anesthesia parameters and thus meets the requirement for continuous documentation of the progress of anesthesia.

It is furthermore possible to monitor and document, through a sampling point in the expiratory branch of the anesthesia circuit, which mixture of substances is fed from the anesthetic machine into the recovery.

If several anesthetic machines are coupled to a single recovery system, it is possible for each mass spectrometer independently of the others to interrupt the gas supply from the recovery in the event of faults or else to block the recovery system entirely. If, for reasons of simplicity, monitoring of the anesthesia circuit is dispensed with, the recovery can also be monitored by a single mass spectrometer which, depending on the number of connected anesthetic machines, is positioned between the recovery gas outlet and the point of branching to the anesthetic machines.

The described analytical configuration can also be used for anesthesia with conventional laughing gas. It is therefore possible to monitor the anesthesia circuit irrespective of the anesthetic gas chosen. This is particularly advantageous when modern anesthetic machines permit operation with xenon or laughing gas as selected. As a rule, no recovery unit is employed for anesthesia with laughing gas. If, for environmental protection or worker safety reasons, in future it becomes necessary for the outflowing laughing gas mixture to be destroyed on site, it will also be possible for such a disposal unit likewise to be monitored, controlled or documented with a mass spectrometer.

The choice of a mass spectrometer with reduced mass range and the described linkage into the system of anesthetic machine and recovery system entirely meet the functional requirements described above and, furthermore, can be implemented at costs which are distinctly below those to be expected with conventional mass spectrometers. This means that the described anesthesia system is reasonably priced and, furthermore, permits economic operation of xenon anesthesia.

BRIEF DESCRIPTION OF THE DRAWING

FIG. **1** shows a diagram of an anesthesia system in accordance with this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1** shows a diagram of an anesthesia system as example. The anesthesia system contains the gas supplies **1** (oxygen source), **2** (xenon source, "first supply"), **3** (xenon store, recovered xenon), an anesthetic machine **10**, control unit **12** (computer or microprocessor), mass spectrometer **11** and monitor **13**, and xenon recovery unit **15**. The ventilation gas is mixed via valves **4** and **5** from oxygen from the oxygen source **1** and from xenon from the xenon source **2** and/or **3**. Valves **4** and **5** are components of a so-called gas mixing box **17**. The ventilation gas (inspired) is fed to the patient via line **22**. The exhaled gas (expired) is fed to the xenon recovery **15** via line **24**. Line **26** leads from the xenon recovery to the xenon store **3**. Line **28** leads from the store **3** via valve **6** into line **20**, which leads into the gas mixing box. Lines **22** (inspired), **24** (expired) and line **26** (xenon recovery outlet) are connected to the mass spectrometer via bypass lines **23**, **25** and **27**. Bypass lines **23**, **25** and **27** each have a controllable valve **7**, **8** and **9**. Valves **4**, **5**, **6**, **7**, **8** and **9** are controlled by the control unit (computer). The control unit also undertakes the conventional control tasks. The mass spectrometer has one or more interfaces (computer interfaces) via which the measured signal, which represents the analytical result, is passed to the control unit. The control unit calculates the content of the gas components (for example oxygen, xenon, nitrogen) from the measured signal. The control unit is connected to the monitor **13** on which all the relevant information is shown. The xenon recovery **15** can take place, for example, as described in DE 44 11 533. Other xenon recovery methods can likewise be employed.

Anesthesia with the anesthesia system advantageously takes place in the following stages (example with xenon as anesthetic gas):

1. At the start of anesthesia, the patient is ventilated with a ventilation gas (oxygen/xenon mixture) and, during this, the composition of the inspired gas and expired gas is determined. In this initial phase, the lungs and airways of the patient are flushed. The expired gas contains nitrogen in this phase.
2. When the composition of the expired gas has stabilized and the nitrogen content has fallen to an acceptable level, the xenon recovery (determination of the starting point of the xenon recovery) is switched on.
3. The anesthesia reaches a stationary phase. The compositions of the inspired gas and expired gas are monitored. It is additionally possible to monitor the composition of the xenon gas from the xenon recovery.
4. The anesthesia is terminated by switching over from anesthetic gas to normal respiratory gas (air). The nitrogen content in the expired gas is of particular interest in this phase. As soon as the nitrogen content exceeds a limit (for example 5 percent by weight), the line with the expired gas is uncoupled from the xenon recovery.

Stages 1 to 4 require continuous monitoring of the composition of the inspired, expired and, advantageously, recovered gases. The monitoring takes place with one or more mass spectrometers. Controlled coupling of the mass spectrometer means that one mass spectrometer is sufficient.

It is advantageous for it to be possible to pick up the measured signal from the mass spectrometer directly on the machine in order to make a safety test possible independently of the control unit. When certain limits are reached, an alarm can be triggered. It is possible when recovered xenon is being fed in, and when the composition of the inspired gas shows an unacceptable difference from the desired value, to switch over to pure xenon from the reserve compressed gas cylinder (xenon source) (Switching over from xenon circulation to first and emergency supplies). It is advantageous for the actual value of the gas composition to be compared with a reference value from a reference gas mixture (for example from a pressure element) either directly in the mass spectrometer or in the control unit. The mass spectrometer can likewise be calibrated using a reference gas mixture from a pressure element. The mass spectrometer is advantageously also arranged so that an alarm is triggered if the pressure in the pressure element falls.

Automation of the anesthesia system may not only relate to computer-assisted control of valves but also comprise control of regulators for setting the gas flow rate. The design of a control for the gas flow rate is familiar to the skilled person.

Conditions for anesthesia with a low gas flow rate are described in the booklet by Jan Baum "Die Narkose mit niedrigem Frischgasfluß" [Anesthesia with a Low Fresh Gas Flow Rate], 2nd edition, Drägerwerk AG, Lübeck, 1994 (ISBN 3-921958-90-3), to which reference is made.

List of Reference Numbers

1 oxygen source
2 xenon source
3 xenon store
4, **5**, **6**, **7**, **8**, **9**, valve, controlled

10 anesthetic machine
11 mass spectrometer
12 control unit (computer)
13 monitor
14 patient
15 xenon recovery
16 pump
17 gas mixing box
20, 21, 22, 23, 24, 25 gas line

What is claimed is:

1. In an anesthesia system having ventilation gas supply flow structure for supplying ventilation gas to a patient, exhaled gas flow structure for receiving exhaled gas from the patient and recycled anesthetic gas-containing gas flow structure for receiving recycled anaesthetic gas, the improvement being a mass spectrometer connected to the flow structures, the mass spectrometer measuring a content of at least one gas component in the ventilation exhaled or recycled anaesthetic gases, and the mass spectrometer controlling flow of the ventilation, exhaled or recycled anaesthetic gases through at least one of the flow structures in accordance with a measured value of the content.

2. Anesthesia system as claimed in claim 1 including structure for the mass spectrometer for simultaneous quantitative measurement of oxygen, anesthetic gas and nitrogen.

3. Anesthesia system as claimed in claim 2, wherein the mass spectrometer controls a safety unit.

4. Anesthesia system as claimed in claim 3, wherein the mass spectrometer is connected via one or more capillaries to one or more measuring points.

5. Anesthesia system as claimed in claim 4, wherein the mass spectrometer is connected via one or more capillaries to the measuring points, and the length of the capillaries is in the range from 1 to 10 meters.

6. Anesthesia system as claimed in claim 5, wherein the mass spectrometer is connected via one or more capillaries to the measuring points, and the capillaries consist of plastic, metal or glass.

7. Anesthesia system as claimed in claim 6, wherein the mass spectrometer is integrated into an anesthetic machine, and the mass spectrometer is attached as backpack to the anesthetic machine.

8. Anesthesia system as claimed in claim 6, wherein the mass spectrometer is integrated into an anesthetic machine or is spatially separated from the machine.

9. Anesthesia system as claimed in claim 1, wherein xenon is employed as anesthetic gas, and the recovery of xenon from the exhaled gas is monitored or controlled by the mass spectrometer.

10. Anesthesia system as claimed in claim 9, wherein the mass spectrometer makes continuous measurements for several measuring points alternately.

11. Anesthesia system as claimed in claim 1, wherein the mass spectrometer controls a safety unit.

12. Anesthesia system as claimed in claim 1, wherein the mass spectrometer is connected via one or more capillaries to one or more measuring points.

13. Anesthesia system as claimed in claim 1, wherein the mass spectrometer is connected via one or more capillaries to measuring points, and the length of the capillaries is in the range from 1 to 10 meters.

14. Anesthesia system as claimed in claim 1, wherein the mass spectrometer is connected via one or more capillaries to measuring points, and the capillaries consist of plastic, metal or glass.

15. Anesthesia system as claimed in claim 1, wherein the mass spectrometer is integrated into an anesthetic machine, and the mass spectrometer is attached as backpack to the anesthetic machine.

16. Anesthesia system as claimed in claim 1, wherein xenon is employed as anesthetic gas, and the recovery of xenon from the exhaled gas is monitored or controlled by the mass spectrometer.

17. Anesthesia system as claimed in claim 1, wherein the mass spectrometer makes continuous measurements for several measuring points alternately.

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